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Agricultural technology for development

Report of the Secretary-General

Summary

Interest in agricultural technologies adapted to smallholders, in particular smallholders who are women, has been revived by the return of high food prices and the need to adapt to climate change. Sustainable intensification of smallholder production will require a shift to knowledge-intensive agriculture that combines local knowledge with the latest scientific research related to sustainability, so as to adapt practices to local ecosystems and increase resilience to climate change and price and other shocks. Poor farmers, often women, usually live in more extreme environments in addition to being less connected to markets. A radical change in the focus of national agricultural plans and substantial investment are needed to unleash the production potential of smallholders, contributing to achieving the Millennium Development Goals and boosting food production to meet the 70 per cent increase needed by 2050. A holistic approach is needed to raise productivity and the resilience of agriculture and supporting ecosystems, and to ensure the efficient and equitable functioning of agricultural supply chains.

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I. Overview

1. The present report has been prepared in response to General Assembly resolution 64/197 requesting the Secretary-General to submit a report to the Assembly at its sixty-sixth session on progress in making appropriate sustainable agricultural technologies available and affordable, especially to smallholder farmers, and making agriculture more resilient, including to climate change.

2. Recent crises have generated wider global political engagement, partnerships and commitments to food and nutrition security,[1] meeting nutritional needs, the right to food and investment in small-scale farmers, including women farmers. A consensus is emerging that achieving sustainable intensification of agriculture, food and nutrition security, farmer resilience and the Millennium Development Goals will require major changes to national agricultural policies, education, partnerships, markets, infrastructure and institutions. Several recent endeavours offer good practices that could be replicated and scaled up. The present report outlines elements of this emerging consensus.

3. The report benefited from inputs from the Food and Agriculture Organization of the United Nations (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Fund for Agricultural Development (IFAD), the International Labour Organization (ILO) and the High-level Task Force on Global Food Security.

II. New context, new paradigm

4. The 2008 food crisis and the recent return of high food prices accompanied by greater price volatility have called into question the current food system, under which the number of undernourished people has increased by almost 10 per cent between 1990/92 and 2010.[2] Smallholder and family farmers, despite being the major producers of food, especially in developing regions, are the majority of the world's poor people and a very large proportion of the chronically undernourished. Boosting agricultural productivity, in particular of smallholders, is one of the most effective ways of addressing global poverty and improving food and nutrition security. Increasing output in agriculture is two to four times more effective in reducing poverty than increases in other sectors.[3] The International Food Policy Research Institute (IFPRI) finds that agricultural research and development has achieved annual economic rates of return of 50 to 66 per cent for investment in areas as varied as the development and release of disease-resistant, high-yielding

[1] Food and nutrition security exists when all people, at all times, can enjoy their right to food and when they have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

[2] *World Economic and Social Survey 2011: The Great Green Technological Transformation* (United Nations publication, Sales No. E.11.II.C.1).

[3] Calestous Juma, *The New Harvest: Agricultural Innovation in Africa* (Oxford, United Kingdom, Oxford University Press, 2011).

cassava varieties, wheat rust resistance and hybrid maize research. Returns to agricultural development projects can yield between 20 and 147 per cent.[4]

5. Food production must increase in the context of growing scarcity of land and water and severe weather related to climate change. Land degradation is affecting productivity, and yield growth — despite large investments in yield-enhancing varieties — is not keeping up with population growth. Soil compaction alone has caused reductions in yields of between 40 to 90 per cent in western African countries, and nutrient depletion also reduces productivity in sub-Saharan Africa and South Asia. Meanwhile, 20 African countries are already experiencing severe water scarcity and another 12 will face water scarcity over the next 25 years.

6. Land degradation is worse in areas where poverty and hunger are concentrated and climate change disproportionably affects smallholders because they are more likely to depend on rain-fed agriculture and degraded land.[2] Resource degradation also specifically affects women, increasing the time they must spend on responsibilities such as food production, fuelwood collection and soil and water conservation.

7. Sustainable intensification of agriculture is the only way to avoid localized chronic food and nutrition insecurity when between 75 and 90 per cent of staple foods are produced and consumed locally.[2] The High-level Task Force has concluded that unleashing the full potential of smallholders, including that of women farmers, is thus key to global food and nutrition security, creation of decent work and sustainable intensification of agriculture. FAO estimates that giving women better access to land, inputs and technology could increase yields by 2.5 to 4 per cent and reduce undernourishment by 12 to 17 per cent.[2]

8. In the future, the path to sustainable growth in agricultural productivity will differ considerably from the green revolution approach. Smallholders must be at the centre of food systems that are well adapted to agroecosystems so as to increase both environmental and economic resilience. Tailoring sustainable agricultural practices to agroecosystems allows for higher diversity and thus greater protection against invasive pests and extreme events. It also permits diversification of income while reducing food production's reliance on fossil fuels with their increasingly volatile prices.[5]

9. Agriculture — which includes growing crops, rearing livestock, producing fish and maintaining forests — in developing countries must undergo a significant transformation to meet the challenges described above. This new paradigm for agriculture will require that smallholders are at the centre of innovation systems, helping to shape the agenda for research and development and extension services so that the crops, fish and livestock products that matter to them as producers and consumers receive adequate attention.[6] It also requires radical changes in existing policies, changes that would result in a strengthening of currently fragmented systems of innovation, a redesign of the education system and investment in

[4] Nienke Beintema and Gert-Jan Stads, *African Agricultural R&D in the New Millennium: Progress for Some, Challenges for Many* (Washington, D.C., IFPRI, and Rome, Italy, Agricultural Science and Technology Indicators, 2011).

[5] Report of the Special Rapporteur on the right to food (see A/65/281).

[6] FAO, *A Policymakers Guide to the Sustainable Intensification of Smallholder Crop Production* (Rome, Italy, 2011). Available from www.fao.org/ag/save-and-grow/index_en.html.

agricultural development throughout the supply chain and in sustainable resource management through innovative partnerships with farmers.[2]

Empowerment of women

10. The majority of smallholder farmers and rural entrepreneurs in developing regions are women and they play a vital role in rural economies by providing their families with food, water and fuel. Their productive potential remains untapped, however, owing to gender gaps in access to a range of assets such as land, education, technology and productive inputs. In Africa, for instance, women represent 80 per cent of agricultural producers[3] and account for half the agricultural output.[2] Only 5 per cent of landholders in North and West Africa and 15 per cent in sub-Saharan Africa are women, while women represent 40 per cent of the agricultural work force in Africa and in East and South-East Asia.[2] When they own, women own smaller farms.

11. Science and technology offer several proven solutions to many challenges faced by rural women living in poverty, and they provide opportunities for their economic empowerment. These solutions include labour-saving technologies related to women's domestic and productive work, such as water pumps, community water schemes, improved cooking technologies, improved transport of water, wood and crops, improved cultivation techniques, and post-harvest and food processing technologies. Rural women in most parts of the world continue to be underserved by technologies and the poorest women continue to rely on traditional, labour-intensive technologies or use no technologies at all. Because of women's lower education levels and discriminatory practices, such as lesser access to credit and lack of land tenure for women, men benefit from new and improved agricultural technologies more often than women.[2]

12. Agricultural extension continues to play a key role in disseminating technology. Extension methods have changed greatly over the years, generally moving towards more participatory approaches and increasingly making use of new information technologies. However, women farmers continue to face an inherent bias in gaining exposure to extension services and the role of women in agricultural production needs to be taken much more into account in extension services and in technological research on commodities and production processes that are dominated by women. Participatory research programmes involving women in the evaluation of new technologies and in the decision-making process can greatly contribute to the development of agricultural practices that respond to women's needs. For example, several initiatives of the International Rice Research Institute supported by IFAD applied a participatory approach by which women suggested new criteria, such as taste and milling qualities, for variety selection and germ-plasm evaluation for biotechnology research.[7] Reducing the education gap for women and increasing the number of women in scientific and agricultural programmes and of women extension agents (only 7 per cent of extension agents in Africa are women) could also increase the contribution of women to agricultural production.[8]

[7] IFAD, *Rural Poverty Report 2011* (Rome, IFAD, 2010). Available from http://www.ifad.org/rpr2011/report/e/overview.pdf.

[8] See report of the Commission on the Status of Women on the fifty-fifth session (E/2011/27-E/CN.6/2011/12).

13. Mainstreaming gender into agricultural policies and the legal and regulatory frameworks that govern the use of technologies can be facilitated through the FAO Socio-economic and Gender Analysis Programme, which helps Member States to build their analytical and policymaking capacities in reducing gender inequalities that affect participation in development, including access to and use of technologies.

III. National policies and strategies

14. The 2008 food crisis has helped the world to rediscover the need for sound agricultural development plans to achieve food and nutrition security, economic growth and progress in achieving the Millennium Development Goals. This realization helped to reverse a long trend towards disinvestment in agriculture, both by donors and by developing countries.

15. In response to the 2008 food crisis, the Group of Eight and five other donors committed in the L'Aquila Joint Statement on Global Food Security to mobilize $22 billion over three years in support of country-led plans for agriculture, with a coordinated, comprehensive strategy for agriculture and food and nutrition security. As part of the L'Aquila initiative, the Global Agriculture and Food Security Programme, a fund administered by the World Bank, was launched to support country-led agricultural development strategies. In Africa, the fund specifically supports countries that have advanced through the Comprehensive Africa Agriculture Development Programme process. That process, launched at a summit of African heads of State in Maputo in 2003, commits African Governments to spend at least 10 per cent of their budgets on agriculture and includes a peer and technical review process to ensure development effectiveness. The equivalent of $925 million has been pledged so far by Australia, Canada, the Republic of Korea, Spain, the United States of America and the Gates Foundation. Ireland has contributed to the operating costs of the Global Programme.

16. The Global Agriculture and Food Security Programme has helped to speed up the development of national plans. Twenty six African countries have completed their national plans of action on agriculture under the Comprehensive Africa Agriculture Development Programme and 16 have prepared and peer reviewed their national investment plans, often with the support of FAO and the United Nations regional commissions. Following independent technical review of national proposals, the Global Programme has to date awarded 12 grants, to Bangladesh, Cambodia, Ethiopia, Haiti, Liberia, Mongolia, Nepal, the Niger, Rwanda, Sierra Leone, Togo and Tajikistan, that together amount to $481 million (out of $520.2 million received against commitments). Other country proposals, several of which have already been identified as ready for support, will be funded once additional funding is committed to the Global Program account.

17. The United Nations system provides increasingly coordinated support to national strategies for food and nutrition security in developing countries. The High-level Task Force, which brings together 22 organizations, funds, programmes and departments within the United Nations family, the Bretton Woods institutions, the World Trade Organization and the Organization for Economic Cooperation and Development, promotes synergy in this inter-agency work. The work of the Task Force is informed by its Updated Comprehensive Framework for Action, which has promoted alignment of the approaches adopted by the various United Nations

entities towards food and nutrition security issues and is now increasingly being used by Governments, the Group of Twenty (G20), development partners and civil society to plan their own strategies. Drawing on the work of the Task Force, there is an emerging consensus among national and international stakeholders that sustainable intensification of agriculture, with smallholders at the centre and systematic protection systems for the most vulnerable, are central both to food and nutrition security and agricultural development plans. This is echoed in the *Rural Poverty Report 2011* published by IFAD,[7] the *Policymaker's Guide to the Sustainable Intensification of Smallholder Crop Production*,[8] published by FAO, the *World Economic and Social Survey* and *Realizing a New Vision for Agriculture: a roadmap for stakeholders*, published by the World Economic Forum.[9]

18. Progress on the declaration made in Maputo by African Heads of State is variable. The African Union has agreed to a yearly 6 per cent growth target for agricultural gross domestic product (GDP) where agriculture plays a dominant role but, despite 5 per cent growth in GDP, according to IFPRI agricultural GDP in the region grew by only 3 per cent between 2000 and 2008. In a recent report on research and development in Africa, IFPRI finds that, despite significant agricultural investment in eight countries, others, such as the countries of francophone West Africa, are dangerously dependent on volatile external funding sources. Ethiopia, Ghana, Kenya, Nigeria, South Africa, Uganda, the United Republic of Tanzania and the Sudan accounted for an increasing share of regional public agricultural research and development spending (70 per cent) and all researchers (64 per cent) in 2008.

19. Renewed Government commitment to agriculture has resulted in a rise in public agricultural research and development in Brazil, China and India. Brazil and India each spent slightly less on public agricultural research and development than sub-Saharan Africa as a whole (totalling $1.7 billion). China's spending far exceeds any other country, amounting in 2007 to $4.3 billion (in 2005 purchasing power parity prices) according to IFPRI. Investment by these Governments has led to dynamic innovation systems in support of agricultural development.[2] The eight large African countries listed above, with well-funded agricultural research programmes, have led agricultural growth in the region. Growth in spending in Ghana, Nigeria, the Sudan, Uganda and the United Republic of Tanzania — the main drivers of regional growth — was largely the result of significant injections of Government funding. Brazil, India and China are also mostly relying on their own investment, but FAO has found that many other emerging and developing countries have a limited ability to fill the investment gap, even if official development assistance is included.

20. The contribution of investment by donors and development banks has increased as a result of the launch of sizable projects funded through World Bank loans in a number of countries as part of the West and East Africa Agricultural Productivity Programmes. Activities focus on generating and disseminating improved agricultural technologies that address both national and regional priorities, focusing on roots and tubers in Ghana, rice in Mali and the United Republic of Tanzania, cereals in Senegal, cassava in Uganda, wheat in Ethiopia and dairy products in Kenya.

[9] World Economic Forum, *Realizing a New Vision for Agriculture: a roadmap for stakeholders* (Geneva, 2010), prepared in collaboration with McKinsey and Company.

21. In Africa, Malawi offers an example of a holistic approach and inspirational leadership by the President, Bingu wa Mutharika, who put in place a series of policy measures to address agricultural and overall development. He took charge of the Ministry of Agriculture and Nutrition himself, committing 16 per cent of spending to agriculture and initiating a rigorous process of assessment and multi-stakeholder consultation aimed at developing a plan for importing improved seeds and fertilizers for distribution to smallholders at subsidized prices through coupons. Production doubled, but costs were high because of leakages in the coupon system, poor targeting of subsidies, the exclusion of the private sector and lack of farmer training, investment in irrigation and post-harvest support. These lessons were used to improve the programme before returning the portfolio to the line ministry.

Room for improvement

22. Despite progress, a recent review by IFPRI of agricultural institutional developments, investment and capacity at the national, regional and global levels offers four areas to be addressed by Governments, donors and other stakeholders:

(a) Decades of underinvestment in agricultural research and development;

(b) Excessive volatility in yearly investment levels;

(c) Existing and imminent challenges in human resource capacity;

(d) The need to maximize regional and subregional cooperation in agricultural research and development.

23. Few agricultural plans take a holistic approach that takes into account the required rural infrastructure, improvement in market access, provision of extension services and technological capacity-building, coordination among multiple stakeholders in the Government, academia, business and civil society, and the need to address property rights, while setting these within a wider framework of sustainable management of natural resources, especially to address land and biodiversity degradation and overuse and contamination of water tables.[2] Going forward, national plans will also have to take into account adaptation to and mitigation of climate change, by increasing carbon sequestration in agroforestry systems and building resilience to climate shocks. No blanket approach will do. In areas where overuse of fertilizers and pesticides has degraded land and water resources, appropriate policies may include removing fertilizer subsidies and facilitating improved soil and water management. In much of sub-Saharan Africa, by contrast, incentives and means to increase the addition of nutrients to nutrient depleted soils may be needed.

24. Most plans still focus on supply-side interventions, and do not pay enough attention to where the increased production will ultimately go. A supply-chain or cluster approach is needed to increase productivity and the income of farmers, especially smallholders, who are mostly remote from markets and have little access to credit. A supply-chain approach pays better attention to the final market for agricultural goods, taking into account all stages of the agricultural supply chain.[10] Without proper linkages between rural producers and urban consumers, urban

[10] Sunil Sanghui, Rupert Simons and Roberto Uchoa, "Four lessons for transforming African agriculture: to succeed, African countries must narrow their focus and target high-impact projects", *McKinsey Quarterly*, April 2011.

growth cannot spur widespread eradication of rural poverty. In sub-Saharan Africa for instance, growing demand for food in urban areas is increasingly met by imports rather than by domestic production. Improvements in harvesting techniques, post-harvest technologies,[11] storage and cooling facilities in difficult climatic conditions, infrastructure, and packaging and marketing systems are also needed to be able to support sustained improvements in the delivery of quality food produce to market, and hence in farmers' incomes, in developing countries. For the most part, national plans do not include activities to foster interactions among farmers, small and medium-sized enterprises and research centres, which can add value to unprocessed raw material, or to strengthen value chains and the participation therein and benefit therefrom for small farmers. The plans typically do not address the need to work with the private sector and support the creation of well-functioning farmers' groups or cooperatives to promote development of equitable aggregation programmes that allow smallholders to reap the benefits of economies of scale and meet the volume requirements of the increasingly dominant supermarkets. Fiscal policies such as reducing export taxes can also increase exports of processed food, as experienced by Côte d'Ivoire and Ghana.

25. Research by McKinsey finds that the plans of many African countries lack specificity, having a large number of initiatives and activities that are not easily managed and targets that are not easily measured. McKinsey recommends concentrating investment on a value chain of importance to the country, a "breadbasket" region positioned for large productivity increases, or an infrastructure corridor. For instance Brazil took the regional approach by investing heavily in the Cerrado region, while Mali is considering a pilot breadbasket approach in the Sikasso region to raise cereal production in a sustainable way. The United Republic of Tanzania, and Mozambique, Malawi and Zambia working together, are taking an agricultural development corridor approach, concentrating investment in farms and facilities for storage and processing around a major infrastructure project (usually a private sector mining or other infrastructure project).

26. Ensuring that there is a reliable supply of quality seed of adapted varieties requires integrated national strategies for the management of plant genetic resources for food and agriculture. Plant breeding capacities are in decline in most national programmes and furthermore are not linked to development of the seed sector, either by public or private partnerships. This impedes farmers from accessing improved varieties and high quality seeds. Plans need to include practical actions and targeted policy measures that create greater linkage and collaboration between plant breeding, seed systems and conservation stakeholders to make available climate-ready crops and seeds worldwide.

27. Agriculture in developing countries will need substantial and sustained investment in human, natural, physical and social capital to intensify production sustainably. FAO estimates that average annual gross investment of $209 billion is needed in primary agriculture and in downstream sectors to meet the needed 70 per cent increase in production by 2050. Investment of $83 billion annually is needed in developing countries alone.

[11] FAO (2011) estimates that roughly one third of food produced for human consumption is lost or wasted globally.

28. The recently released FAO Policymaker's Guide to the Sustainable Intensification of Smallholder Crop Production provides a toolkit rooted in a new paradigm of agriculture based on sustainable ecosystems, which should help Member States to achieve the above changes.[9] For instance, FAO provides guidance and relevant tools to countries on how to use and conserve the pollination services that sustain agroecosystems, and to formulate policies that will ensure sustainability of these ecosystem services. It also provides guidance on developing national phytosanitary strategies based on international standards to ensure the safe trade of plants and plant products and secure access to international markets, and on support for seed production systems.

29. ILO supports countries to implement the Global Jobs Pact, adopted in June 2009, through seminars, knowledge-sharing tools and office-wide policy briefs. The Pact places employment and social protection at the centre of extraordinary fiscal stimulus measures, with the view that this will protect the vulnerable and reactivate investment and demand in the economy. The Pact is defined and implemented at the national and global levels, based on social dialogue, employment and social protection measures best adapted to each national situation.

IV. Supporting agricultural research and development[12]

30. The yields of many staple foods have been stagnating for more than a decade now, despite huge investment in and adoption of high-yielding varieties.[13] Meanwhile, according to FAO agricultural production needs to double in developing countries by 2050. In many countries, the twin objective of food and nutrition security and environmental sustainability will require, inter alia, greater and well-targeted investment in research and development and wider dissemination of information and technological support to small-scale farmers through adequate extension services and stronger multi-stakeholder partnerships. The public sector needs to invest in research and development and provide adequate incentives to expand research on crops and processes that are relevant to the poor. FAO notes that research and development is now dominated by the private sector, concentrated in six major companies focusing mainly on profitable developed country markets. Private-sector funding can be facilitated by an enabling policy environment, including strong intellectual property legislation, minimal barriers to importing and testing new technologies and tax exemptions on research expenditures.

31. In the case of Africa, eight countries have increased their research and development in agriculture but several others are grossly underfunded. Even in the eight countries with well-developed research systems, support for research varies considerably from year to year, notably in South Africa and Kenya.

32. Nigeria has the largest agricultural research system in sub-Saharan Africa in terms of investment, capacity and the number of government and higher education institutions. Public agricultural research and development more than doubled during 2000-2008, offsetting an earlier decline, salary levels increased and a freeze on

[12] The majority of information in section IV comes from the IFPRI Agricultural Science and Technology Indicators, used to track agricultural institutional developments, investments and capacity at the national, regional and global levels.

[13] *CIAT Annual Report 2010: From the New World to the Whole World* (Cali, Colombia, International Centre for Tropical Agriculture, 2011).

government recruitment was lifted. The role of the higher education sector in agricultural research was also increased during this time.

33. In Africa, 16 countries have created academies of science (Ghana, Cameroon, Egypt, Ethiopia, Kenya, Madagascar, Mauritius, Morocco, Mozambique, Nigeria, Senegal, South Africa, the Sudan, Uganda, the United Republic of Tanzania and Zimbabwe) that should help in integrating knowledge. However, despite the infrastructure development needed in Africa, only South Africa has an academy devoted to promoting engineering. Regional integration is also helping collaboration and information-sharing among national research centres in sub-Saharan Africa. The Forum for Agricultural Research in Africa, the Association for Strengthening Agricultural Research in Eastern and Central Africa, the West and Central African Council for Agricultural Research and Development and the Food, Agriculture and Natural Resources Directorate of the Southern African Development Community have all made considerable progress in coordinating agricultural research activities in their member countries through the establishment of various research networks. They allow national agricultural research systems to specialize in certain fields and have proved to be particularly beneficial for small countries that lack a critical mass in agricultural research and development.

34. Lessons from the green revolution and the Consultative Group on International Agricultural Research (CGIAR) are that: (a) innovation and development of new technologies requires long-term secure financing and commitment; and (b) adoption of new technologies requires an enabling institutional framework and large investment in infrastructure and capacity development among farmers, as well as access to inputs, credit and markets.[2]

35. Public research institutions also require a radical change in their current model of operation so as to improve their responsiveness to the needs of farmers, including through joint experimentation and learning. IFAD is attempting to address these needs through a grant to the International Fertilizer Development Center to fine-tune and scale up innovative approaches for developing site-specific, integrated soil fertility management options, appropriate (including organic) fertilizers, mechanisms for enabling access to fertilizers by resource-poor farmers, increased adoption of soil management options, and desirable institutional, behavioural and policy changes in West Africa.

36. Participation of women in agricultural research and extension services, especially in sub-Saharan Africa, will be critical to ensure their particular needs are met. IFPRI has reported that some countries, such as Botswana, Mozambique and South Africa, have larger shares of female professional staff in agricultural research and higher education (32 per cent, 35 per cent and 41 per cent, respectively), while others have very low levels, such as 6 per cent in Ethiopia, 9 per cent in Togo, 10 per cent in the Niger and 12 per cent in Burkina Faso.

Consultative Group on International Agricultural Research

37. Budgets allocated to CGIAR grew from $15 million in 1970 to $305 million in 1990 and reached $600 million in 2011. The cost-benefit ratio of the CGIAR research has been estimated to range from 1.9 to 17.3 based on a subset of its

research.[14] This institution, which supported the green revolution, is undergoing significant reform, which in 2010 resulted in a new structure based on a results-based management approach for strategic planning, management and communications centred on continuous learning and accountability. The new system level outcomes that inform the design of CGIAR research programmes are: (a) reducing rural poverty; (b) improving food security; (c) improving nutrition and health; and (d) sustainable management of natural resources. Priority is increasingly given to responding to local needs (including applied and operational research), validating and disseminating field experience and good practices and building the capacity of national institutions.

38. In 2010, IFAD approved grants amounting to $13.6 million to the 15 CGIAR-led programmes (now extended to the Global Forum on Agricultural Research) which promote worldwide collaborative research partnerships. Through information-sharing and assessment of innovative policies and programmes, IFAD partnerships with the various CGIAR centres support efforts to improve access to productive assets and new markets for high-value commodities. For example, IFAD works with Biodiversity International to raise the profile of neglected and underutilized species and to support provision of improved seeds to poor rural communities in India, Peru, the Plurinational State of Bolivia and Yemen.

United Nations system

39. FAO assists 60 countries with capacity-building technical assistance projects. These projects assess the current state of agricultural innovation systems; strengthen the capacity of the research, extension, education, information and communication institutions and services; provide methods and tools to strengthen the linkages between traditional and scientific knowledge generation; and develop management and policy mechanisms to strengthen the agricultural innovation system and to make it more sustainable.

40. FAO leads several initiatives that enhance the dissemination of the outputs of agricultural research and innovation including: (a) the Coherence in Information for Agricultural Research for Development initiative, which provides a framework of good policy and practice supported by a range of open tools and services for organizations to make public domain outputs truly accessible, now supported by more than 100 major research organizations and universities; (b) the Access to Global Online Research in Agriculture programme, which provides free or extremely low-cost access to 2,700 online published scientific articles to over 2,500 registered institutions in 107 low-income countries; and (c) the conceptual model for the Virtual Extension and Research Communication Network, which promotes the use of Internet-based technologies and communication to increase linkages among agricultural policy, research and extension institutions and other key stakeholders.

Integrating local know-how

41. An interesting trend in supporting knowledge-intensive agriculture is the recognition of the role of decentralized universities as agents of regional knowledge

[14] David Raitzer and Timothy Kelley, "Benefit-cost meta-analysis of investment in the international research centers of the CGIAR", *Agricultural Systems*, vol. 96, Nos. 1-3 (March 2008).

transfer. The decentralization of knowledge to a variety of local institutions will be key to integrating local knowledge and new technology to adapt them to local agroecosystems and to climate change. For instance, the Government of Ghana established the Multi-campus University for Development Studies in 1992 with the goal of making tertiary education relevant to rural communities in northern Ghana using resources from the region. The pedagogical approach emphasizes practice-oriented, community-based, problem-solving, gender-sensitive and interactive learning applied to local poverty problems.[15] Students are expected to understand the importance of local knowledge and to find ways to combine it with science through practical field programmes involving participatory learning and appraisal, during which students live and work in rural communities.[15] The majority of graduates of this university are now working in rural communities. Uganda has developed similar community-based agricultural education.

42. FAO supports the integration of local know-how by providing links and building communication channels for knowledge exchange between United Nations agencies and other stakeholders. FAO also provides advice and technical assistance to countries in identifying communication needs and in applying innovative, cost-effective communication strategies for specific audiences. The principle of "Communication for development", supported by FAO, is a critical component of any development initiative to ensure knowledge is effectively shared among people and institutions. UNESCO also fosters the use of traditional knowledge in several selected biosphere reserve projects around the world (such as in Cuba and Morocco) that provide lessons for Governments.

Land and water

43. Agriculture and land are closely linked. Addressing the nexus of food, land, water and energy security, environment and climate change is vital for an agricultural sector to be able to meet an increasing demand for food staples and to be environmentally, socially and economically sustainable. Agriculture and water are also closely linked. Worldwide, agriculture consumes 70 per cent of all withdrawals of freshwater, an increasingly scarce resource. Agricultural water productivity has to be increased significantly to raise yields and cope with climate change. Adaptation efforts must begin now to avoid building infrastructure that locks agricultural users into unsustainable behaviour for years to come. Integrated land and water resources management, efficient use of water resources and safe reuse of wastewater will be vital in both adaptation to and mitigation of climate change. African examples of rainfed systems include raised seedbeds to trap water and keyhole gardens using wastewater. Improved irrigation systems include mini-sprinkler and drip systems, precision timing in plant watering and crop systems, such as the intensive rice system, that use less water than traditional systems. Improved water harvesting and retention are also fundamental for increasing production. For instance, one pilot project using an earthen dam to collect rainwater to permit irrigation during the dry season has doubled rice yields in Costa Rica, Mexico and Nicaragua.[13]

[15] Juma. *The New Harvest*.

V. Supporting technology transfer and extension services

44. Radical reform of and support for technology transfer and extension services are needed to meet the challenges of food and nutrition security, poverty reduction and environmental sustainability. After decades of underinvestment, many developing countries have weak agricultural innovation systems that are fragmented and poorly linked with farmers, civil society organizations and the private sector. Yet, agricultural extension workers are still an important vehicle for the transmission of knowledge, information and training for small farm holders, provided that they have adequate training themselves, a clear mandate and adequate remuneration.

45. Successful adoption of sustainable practices have in common:

(a) Technical knowledge is made relevant and accessible to farmers and farmers are directly involved in learning and innovation aimed at adapting knowledge, technology and management practices to the local context;

(b) Active participation of various actors including Governments, non-governmental organizations, private companies and multilateral organizations in scaling up innovations, disseminating knowledge, building capacity among farmers, fostering trust and reducing the risks of new technology and agricultural practices;

(c) Adjustments in institutions governing agricultural research and development to induce farmers to adopt new practices, redefining the role of women and establishing closer interacting networks;[16]

(d) An enabling environment within which farmers can overcome the constraints they face in adopting new technology and agricultural practices.[2]

46. Several effective collaborations among multiple stakeholders have been successful in designing and deploying innovations with large-scale impacts including farmer field schools and the system of rice intensification, among others.[2]

47. The experience of the farmer field schools, which are operating in 87 countries, shows that innovation and flexible natural resource management can be advanced through farmer-to-farmer learning, with participation from formal and informal research institutions. The schools involve a participatory approach that allows small farm holders to test technical alternatives and adjust them to local conditions and ecology. A partnership between the Government of Indonesia, the United States Agency for International Development and FAO has expanded farmer field schools from Indonesia and the Philippines to Bangladesh, Cambodia, China, India, the Lao People's Democratic Republic, Nepal, Sri Lanka and Viet Nam and has also extended the content to include a range of management skills. Scientific evaluation is needed, however, to ensure that farmer field schools are an effective tool to disseminate knowledge. Some have found that farmer field schools are not easily scalable and that they have had contestable impact on the sustainability of agricultural intensification.[17]

[16] IFAD, *Rural Poverty Report 2011*.

[17] Kristin Davis, "Farmer field schools: a boom or bust for extension in Africa?" *Journal of International Agricultural and Extension Education*, vol. 13, No. 1 (Spring 2006).

48. In-service and on-the-job training and distance education via mobile telephony, video and radio have also proved effective and are increasingly complementing extension services. FAO facilitates the e-Agriculture global community of practice that was established after the World Summit on the Information Society to foster the more effective use of information and communications technology (ICT). Over 7,000 information and communication specialists, researchers, people in rural institutions, farmers, policymakers and business people from more than 160 countries share good practices and information about the use of ICT for sustainable agriculture and rural development.

49. Mobile telephony now provides an affordable and accessible means of communication and support to bring innovation to rural communities so as to create economic opportunities and strengthen social networks. The implementation of local innovation and communication plans by FAO has improved the delivery of advisory services, the use of local knowledge and participation by farmers in decision-making, enhancing research, extension and linkages among farmers. Special emphasis has been given to promoting the sustainable management of natural resources in agriculture. Farmers and communities have used mobile telephony to do electronic banking and to access real time weather, price and other information. FAO uses mobile telephones to monitor the incidence and spread of infectious pests and diseases, use and disposal of government pesticide stocks, location of water sources and regional price changes.

50. Videos of peers practising improved management have proven to be very effective with African women, more so than training workshops.[15] For instance, in Benin videos have been used to introduce women to improved rice processing techniques. These can be reinforced through radio programmes, as does Radio Guinée Maritime. These low-cost technologies are underutilized in fomenting innovation through farmer-to-farmer knowledge-sharing.

51. The system of rice intensification was developed outside formal research institutions, mostly by non-governmental organizations and farmers through continuous learning and adaptation. The system implements simple management changes such as hand transplantation in non-flood fields of younger plants, with higher spacing between them and broader use of organic fertilizer and integrated pest management. It has been successfully tested in 40 countries, increasing yields by 50 per cent while reducing water use and input costs, thus increasing incomes. The Governments of Cambodia, China, India, Indonesia and Viet Nam have endorsed the system of rice intensification and included it in their national strategies for food security.

52. Rapid expansion of quality education in rural areas, including adult and women literacy and training, will also be needed to ensure farmers have the ability to innovate, learn from one another and adapt to change in agroecological and market conditions.

53. To provide a forum for sharing of experience in the rural advisory services sector, FAO has supported the formation of the new Global Forum for Rural Advisory Services. The Forum has 34 regional and national affiliates with which it is consulting to develop a five-year operational plan and a guidance kit for evaluating rural advisory service systems and developing evidence-based approaches and policies for improving the effectiveness of these services and programmes.

54. FAO also stimulates the sharing of knowledge between applied research and field extension agents through TECA, an information system that provides an Internet-based platform to share knowledge on applied technologies and practices for small agricultural producers and online exchange groups on specific geographical areas or themes. The new platform was tested with rural users and reviewed to contain only well-described technologies and practices that comply with the needs of rural users (300 technologies and practices). On average about 10,000 pages of the platform are viewed per month and awareness activities are ongoing. The modules can be decentralized to Member States, as was done with the Plurinational State of Bolivia.

55. The Asian and Pacific Centre for Agricultural Engineering and Machinery of the Economic and Social Commission for Asia and the Pacific has developed an institutionalized process for testing and promoting safe and sustainable machinery for the region through pilots using harvest and post-harvest technologies in Myanmar and high-yielding rice cultivation and seed production technology in the Democratic People's Republic of Korea, Fiji and the Philippines (see E/ESCAP/67/6).

VI. Market and financing services

Market services

56. While the private sector has played an increasingly important role in accelerating innovation in agriculture through a variety of mechanisms, the risk of excluding small-scale farmers is high. Large supermarket chains control between 40 and 50 per cent of the food market in Latin America and the Caribbean, about 10 per cent in China, 30 per cent in South Africa and 50 per cent in Indonesia, requiring smallholders to have the capacity to meet strict quality standards and develop aggregation of their products through cooperatives and associations to reach the scale required for commercialization.

57. Three factors are critical in preventing smallholder exclusion from the supermarket supply chains that are increasingly dominating procurement in developing countries: (a) a focus on products with a pre-identified market; (b) the catalysing involvement of private and/or public organizations with a commercial basis; and (c) sustainable group formation among farmers. Monopolistic practices in food markets must also be prevented.[18] Better access to information, credit and risk insurance would also leave small farm holders in a better position to engage in mutually beneficial partnerships with the private sector.[2]

58. In addition, the proliferation of ethical and environmental certification processes in recent years is opening new opportunities for creating value chains that link small farm holders to larger export markets. Voluntary standards and certification programmes for bananas, coffee and cacao address a wide range of issues including environmental protection, labour rights, safety and health at work, social equity and the welfare of local communities, while providing farmers with price premiums and improving market access and stability.

[18] Ellen McCullough, Prabhu Pingali and Kostas Stamoulis, eds., *The Transformation of Agri-Food Systems: Globalization, Supply Chains and Smallholder Farmers* (FAO and Earthscan, 2008).

59. Nevertheless, FAO notes that standards aimed at food safety, quality, traceability and good agricultural practices, which are mainly developed by large firms in major markets, tend not to ensure price premiums and may harm small-scale growers by significantly raising the costs they incur to meet the standards. In response to this proliferation of standards, the non-profit and volunteer-based consortium Committee on Sustainability Assessment has developed a rigorous assessment tool and is now generating science-based information on the social, economic and environmental impacts of any sustainability practices — including their costs and benefits over five years. The tool has broad political acceptance with development agencies and leading firms because of its multi-stakeholder consultation process. The Committee is expanding data collection, including on coffee, tea, cotton, biofuel crops and fruits, and will provide agricultural sustainability information for dozens of countries. Data collection, of more than 5,000 data sets so far, is done by strengthening the capacity of leading local organizations in developing countries to collect data according to a standard method, making state-of-the-art impact assessment publicly available.

60. FAO has also developed a work programme to provide advice on: (a) changes in government engagement with the private sector to reflect the diversity and changing markets; (b) the creation of an enabling environment for national agribusiness development; and (c) institutional strengthening and services sector development to support agricultural value chain programmes for sustainable and inclusive business development.

Financing investment and innovation

61. Publicly funded research should maintain an explicit focus on strategic priorities for food and nutrition security, including improving yields and resistance of staples, improving the nutritional value of crops, facilitating sustainable use of natural resources and/or reducing the use of external chemical inputs, and increasing resilience and adaptation to market conditions and climate change. Investments in agriculture are also a cost-effective way to build resilience and reduce the need for humanitarian aid year after year in regions facing chronic food and nutrition insecurity.

62. Governments and donors are increasing investment in agriculture but more is needed to meet the growing demand for food. Progress on the declaration by African Heads of State in Maputo must be stepped up and delivery against the L'Aquila commitments will be an important step forward. With the economic and financial crisis however, public sector contribution to agriculture and rural development has been very variable, with a significant number of countries showing low or declining contributions.

63. It is estimated that private sector investment in agriculture, including foreign direct investment, will need to increase by nearly 50 per cent overall to meet increasing demand (from some $142 billion per year). Yet there is evidence that current investments are frequently made with weak consultation with local communities, a lack of transparency over the terms of investment, and poor or non-existent mechanisms to redress grievances related to exploitation of natural resources, large-scale land acquisition and loss of livelihoods in rural communities. FAO has noted that there is increasing evidence that alternative models that include smallholders, such as contract farming, outgrower schemes and joint-ventures with

farmer organizations, are more conducive to sustainable economic development than the large-scale land acquisition model to create mega-farms in developing countries. Traditional pubic-private partnerships have also not been very successful in directing innovation efforts towards achieving sustainable development objectives.[2] To facilitate private investment that is responsible and fosters sustainable development, at the request of the G20, FAO, IFAD, the United Nations Conference on Trade and Development and the World Bank developed the Principles for Responsible Agricultural Investment that Respects Rights, Livelihoods and Resources. The G20 has proposed that the organizations pilot the seven principles that have arisen from consultation in a first phase and use lessons learned to inform a consultation process for a second phase.

64. Approaches which integrate and blend all sources of financing acceptable to each country will be needed.

65. While it still needs to be tested in agriculture, the advanced market commitment mechanism for the production of vaccines, whereby donors make a large advance purchase commitment at a predetermined price, may offer significant lessons for technological innovation for sustainable agricultural intensification.

66. Another innovative mechanism to engage the private sector is the results-based performance contract, for the development, for example, of improved seed or crop varieties with higher water-stress tolerance and greater responsiveness to fertilizers, granted on a competitive basis; this may be one means of stimulating private research.

67. Industry partners of the World Economic Forum have contributed through regional consultations in Africa and Asia to develop the New Vision for Agriculture, whose road map was released at the annual Forum meeting in Davos, Switzerland, in January 2011. The road map focuses on partnerships among the public sector, the private sector and civil society, with farmers at the centre, to accelerate growth of sustainable agriculture.

68. Implemented in conjunction with the African Union, the New Partnership for Africa's Development and national Governments, these partnerships work towards sustainable intensification of smallholder agriculture and better functioning value chains involving businesses (including farmer organizations), civil society organizations and Governments.

69. It is also important to learn from the range of pilot climate funds currently under implementation especially with respect to creating enabling environments for responsible private sector investment, both small-scale and large-scale, including partnerships with philanthropic organizations and foundations. Including sound agricultural practices in financial mechanisms such as REDD Plus could help to finance sustainable intensification. Agriculture contributes significantly to climate change by producing 10 to 12 per cent of total global anthropogenic emissions of greenhouse gases. Sustainable agricultural practices can significantly reduce emissions by storing carbon in the soil or in above ground biomass, or by reducing nitrous oxide or methane emissions. Another source of funding being explored is access to the funds made available under the Copenhagen Accord adopted at the United Nations Climate Change Conference in 2009 as fast-start finance for enhanced action on mitigation (including REDD), adaptation, technology

development and transfer, capacity-building and long term support, though which the aim is to mobilize $100 billion per year by 2020.

70. FAO and interested G20 members are working to develop a platform for capacity-building in tropical agriculture in developing countries, which will bring together institutions from G20 countries and least developed countries in a virtual, agile and efficient structure to generate and apply agricultural knowledge in developing countries. The Platform is aimed at global coordination of efforts to develop the capacities of individuals using good training practices that support continuous learning and ownership by national actors.

VII. Way forward

71. Sustainable intensification and sustainable agriculture will remain high on the international agenda as food production must increase by 70 per cent over the next 38 years and investment must increase by $209 billion per year. The United Nations Conference on Sustainable Development in 2012 will provide an important opportunity to foster the launch of partnerships that lead to agricultural innovation, agricultural technology transfer and adaptation, and innovative financial mechanisms to support these innovations. Sustainable intensification of agriculture is central to one of the two themes of the Conference: a green economy in the context of sustainable development and poverty eradication.

72. Significant national efforts will be needed to reform the agricultural sector to integrate sustainable agriculture and support to smallholders, including women farmers, into national policies and strategies, supported by regional and international institutions. Greater effort and resources need to be devoted to developing and diffusing agricultural technologies for effective adaptation to climate change and natural resource scarcities. Agriculture also has the potential to wed techniques for greenhouse gas mitigation with improved livelihoods for poor farmers through low-cost improvements in soil, water, plants and ecosystem management.

73. Investment and cooperation in reducing post-harvest waste in developing countries would go a long way towards addressing food and nutrition security and poverty while saving precious natural resources. Other investments in infrastructure and capacity-building for meeting certification standards would help enhance the access of smallholders to national and international markets.

74. The deficit of women in key education, research and extension services supporting agriculture must be explicitly addressed. Gender analysis and targeted initiatives must be incorporated into agricultural education, research and extension services, acknowledging the roles women play in the agricultural workforce as the main food producers and in the household as caretakers. Women are to be seen as visible actors and participate on an equal footing in the development of any intervention aiming to promote food and nutrition security.